Methods to Increase Efficiency in Heat Transfer within a Wiring Device

Cross-Reference to Related Applications

[0001] The following applications/patents are hereby incorporated by reference in their entirety: U.S. Patent No. 9,368,982, which issued on June 14, 2016 to Jansen et al.; U.S. Patent No. U.S. 9,496,726, which issued on November 15, 2016 to Frid et al.; U.S. Patent No. 10,433,455, which issued on October 1, 2019 to Jansen et al.; U.S. Pat. No. 10,923,941 which issued on February 16, 2021 to Jahan et al.; WIPO Publication No. 2020/060740, which published on March 26, 2020 to Jahan et al.; U.S. Application Serial No. 17/177,100, which was filed on Feb. 16, 2021 to Sanghvi et al.; U.S. Application Serial No. 17/268,935, which entered the U.S. National Stage on February 16, 2021 to Jahan et al.; and WIPO Application Serial No. PCT/US2021/018222, which was filed on February 16, 2021 to Sanghvi et al.

Brief Description of the Drawings

[0002] By way of example, a specific embodiment of the disclosed device will now be described, with reference to the accompanying drawings, in which:

[0003] **FIG. 1** is an isometric view of a mounting strap of a wiring device according to the disclosure;

[0004] **FIG. 2** is an isometric view of the mounting strap showing a path of heat flow through the mounting strap towards the front of the mounting strap a portion of the system of **FIG. 1**;

[0005] **FIGS. 3** and **4** are views of a heat generating surface mounted component on a printed circuit board (PCB) and a thermal pad that provides thermal communication between the heat generating surface mounted component and the mounting strap;

[0006] **FIGS. 5** and **6** show cutaway views of a wiring device. The arrows showing a clear path from the transformer (grey cube in the center) and the front of the wiring device. Note the terminals are positioned close to the exterior of the wiring device housing.

[0007] **FIG. 7** shows a PCB subassembly of the wiring device;

[0008] **FIG. 8** shows the dielectric barrier (transparent element) when it is installed around the PCB subassembly;

[0009] **FIG. 9** shows a dielectric barrier (translucent element) as installed in the final assembly. The dielectric barrier is between the PCB subassembly and the aluminum housing of the wiring device housing (transparent element);

[0010] **FIG. 10** shows a molded insert providing a support for the PCB assembly;

[0011] **FIG. 11** shows ground path from the ground pin terminal and strap through the ground wire;

[0012] **FIG. 12** shows a molded insert (dark grey) that mates into the aluminum housing; the cavity in the side of the molded insert near the rear (refer to the arrow) provides for clearance to accommodate internal ribs commonly found in electrical boxes;

[0013] **FIGS. 13** and **14** shows how the molded insert protects both internal and external wires against sharp edges of the aluminum housing.

DETAILED DESCRIPTION

[0014] The following disclosure is intended to provide exemplary embodiments of the disclosed system and method, and these exemplary embodiments should not be interpreted as limiting. One of ordinary skill in the art will understand that the steps and methods disclosed may easily be reordered and manipulated into many configurations, provided they are not mutually exclusive. As used herein, “a” and “an” may refer to a single or plurality of items and should not be interpreted as exclusively singular unless explicitly stated.

[0015] Universal Serial Bus (USB) charging devices are operating at increasing power levels, thus generating greater levels of heat (e.g., USB with Power Delivery devices). The disclosed apparatus, systems, and methods allow

for a wiring device (e.g., a USB charging device) to cool more efficiently and allow for the device to operate longer without using the reducing charging power.

[0016] The wiring device is provided with a wiring device housing. The wiring device housing includes an aluminum housing and the power conversion printed circuit board (e.g., power PCB). The power PCB is mounted as close to the aluminum housing as possible. The power PCB may generate substantial heat since it includes components (e.g., a transformer) needed to convert line voltage (e.g., 120 or 240 VAC) to low voltage (e.g., 5. 10, 15, or 24 VDC). The power PCB is a circuit board with surface mount components and through-hole components. The surface mounted components are on the side of the PCB facing the rear surface of the wiring device. The through-hole components, including the transformer are on the side of the PCB facing the front face of the wiring device. This allows the PCB to be aligned and positioned as close as possible to the aluminum housing. As such, heat generating components are also as close to the aluminum housing for good heat transfer (there is less air space between these surfaces to act as insulation). This construction allows for heat sinking, using thermal pads and heat spreaders when necessary. If a thermal pad is used, it bridges the gap between one or more of the surface mounted components (e.g., an integrated circuit chip) and the aluminum housing, thus ensuring good heat transfer.

[0017] By using an aluminum housing, a very large surface area is provided which allows for greater heat dissipation from inside the wiring device (and from inside an electrical box) towards an outside environment (e.g. a room of a house). Additionally, heat can flow through the housing and out the front side of the wiring device (e.g., through the integrated mounting ears).

[0018] Referring to Figs. 5 and 6, obstructions have been minimized between the interior side of the PCB and the front face cover. Minimizing and/or removing such obstacles (e.g., a middle housing, additional logic PCB's, wiring terminals, and insulating surfaces) provides for the maximum free convection (e.g., a clear path for internal air flow) from the power PCB towards the front face of the wiring device. In addition, the wiring terminals are located as close as possible to the outside walls of the housing to keep the middle area of the housing clear. The front face of the wiring device is exposed to the outside environment (e.g., a room). The outside environment provides a large temperature differential and large volume. The combination of the temperature differential and the volume of air can be used to draw the heat from within the wiring device (and from within the electrical box).

[0019] Referring to Figs. 3 and 4, a thermal pad is used to transfer heat directly from one or more heat generating surface mounted component to the aluminum housing (instead of relying on air to conduct heat).

[0020] One or more logic PCB(s) are positioned within the housing at a right angle with respect to the power PCB and are located as close as possible to the outside wall of the housing. This construction keeps the middle area of the housing clear, therefore enabling greater heat transfer. By doing so, the need for a middle housing between the logic PCB and the power PCB is eliminated. This is especially true since the logic PCB(s) don't block heat transfer from the power PCB to the front face of the wiring device. The transformer, which may generate a significant amount of heat, is located on the side of the power PCB towards the front face of the wiring device and is thus not blocked by the logic PCB(s).

[0021] Referring to Figs. 8 and 9, a material liner surrounds the PCB's and provides a dielectric barrier between the PCB's and one or more components, such as the molded inserts and the aluminum housing. Therefore, the PCB's are completely isolated from the aluminum housing. The material liner can be made of any suitable material such as fiber, paper, and polymer (e.g., multi-layer polycarbonate).

[0022] Referring to Fig. 11, an internal ground strap is included and is attached with screws to the aluminum back housing. A ground wire is attached to ground strap via eyelet and ring terminal.

[0023] Referring to Fig. 12 through 14, a molded back housing insert is provided which fills the gaps between the various components and the aluminum housing.

The molded back housing protects both internal and external wiring from the sharp corners of aluminum housing.

[0024] The features disclosed in the foregoing description, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any combination of such features, be utilized for realizing the invention in diverse forms thereof.

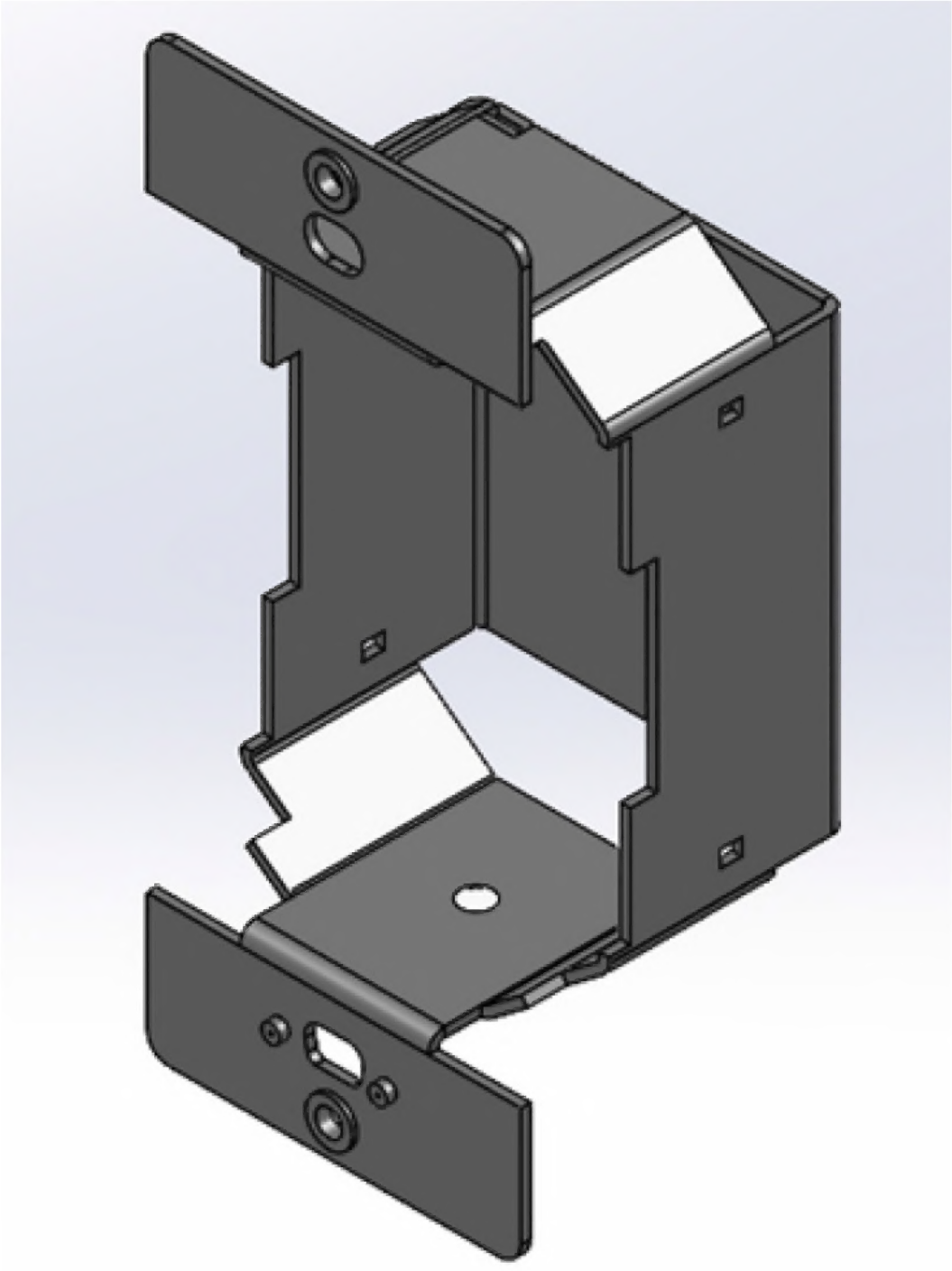

FIG. 1

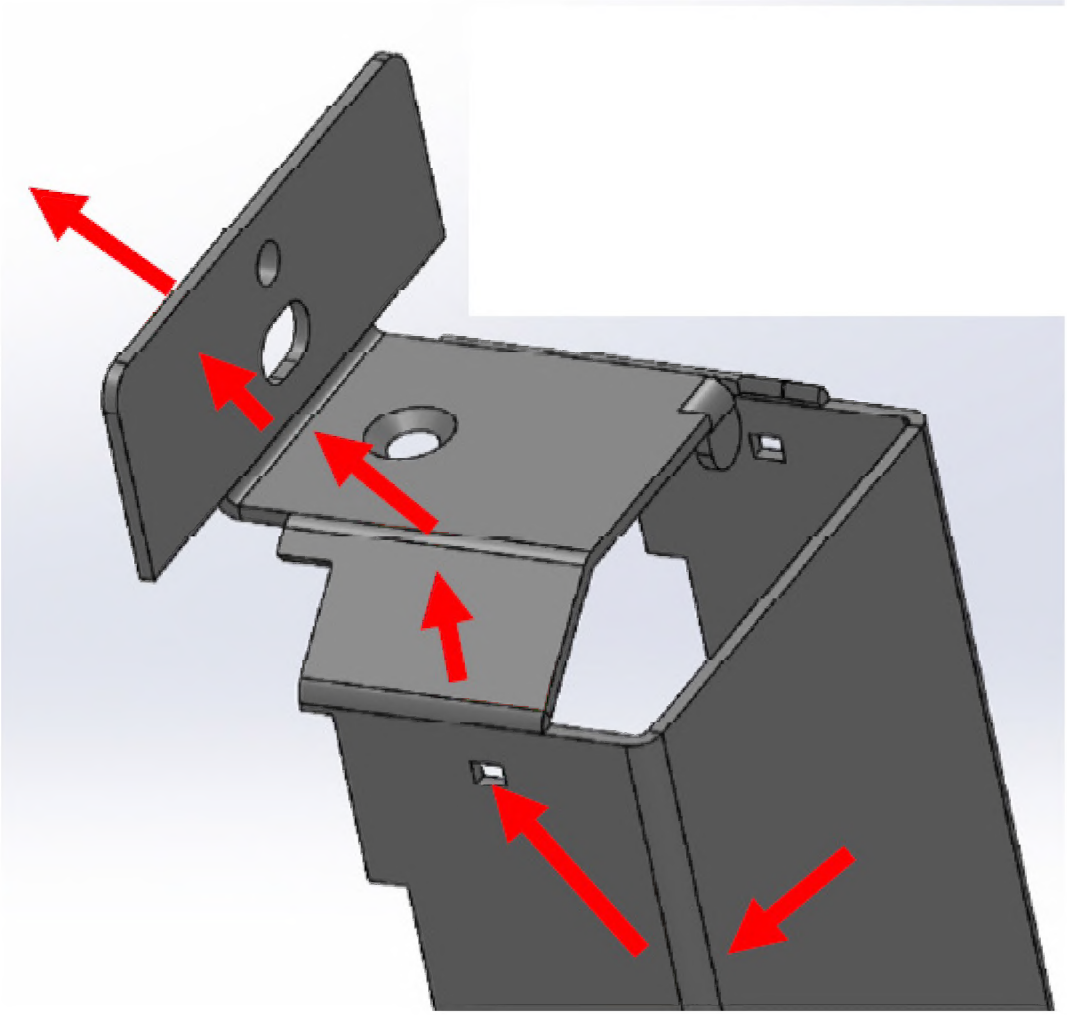

FIG. 2

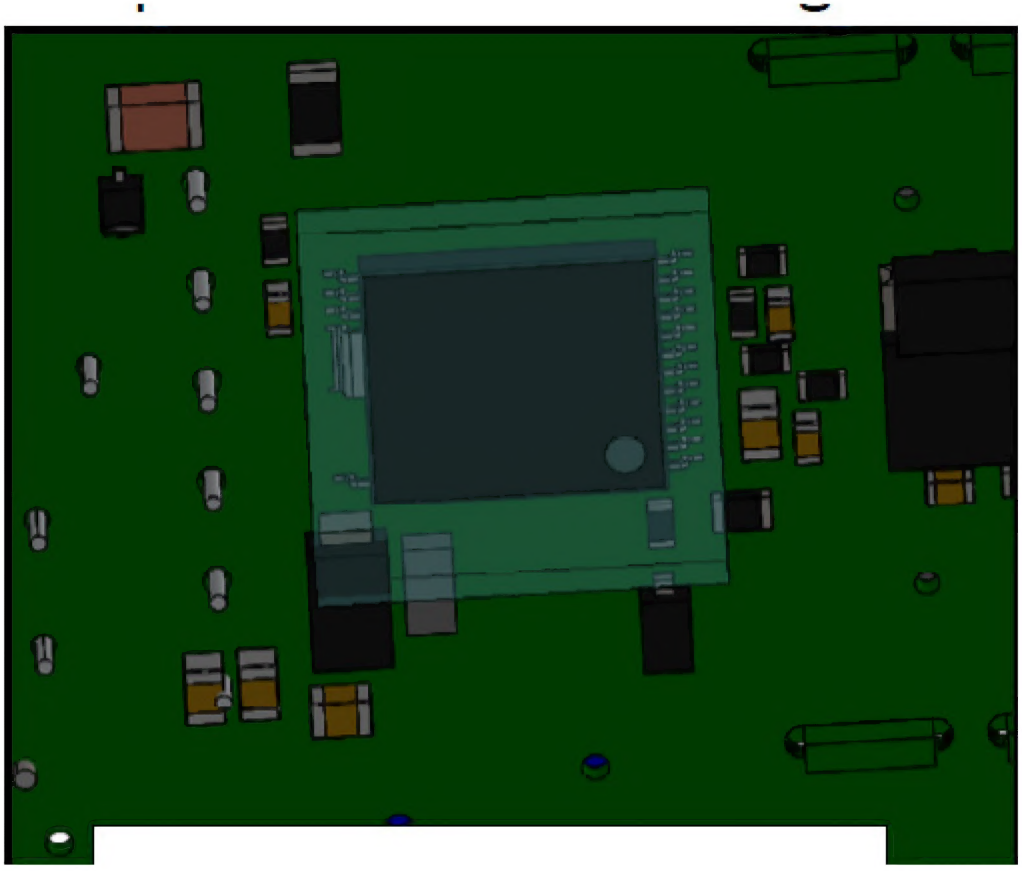

FIG. 3

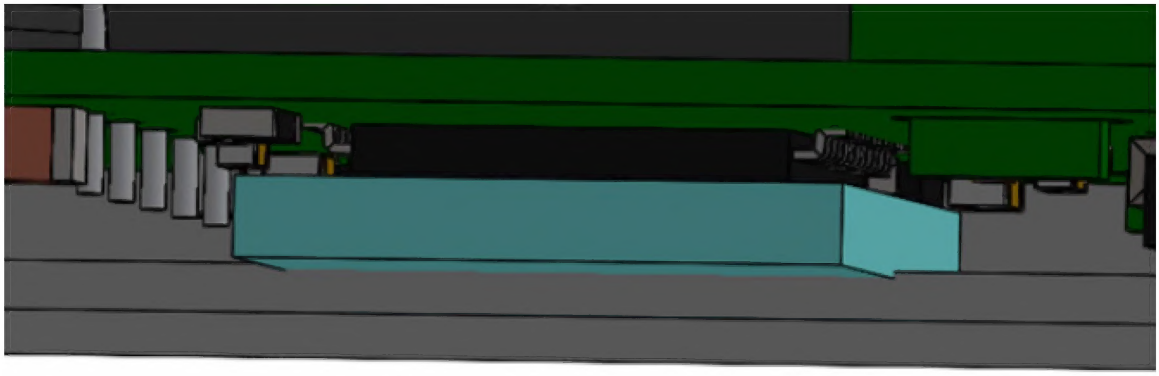

FIG 4.

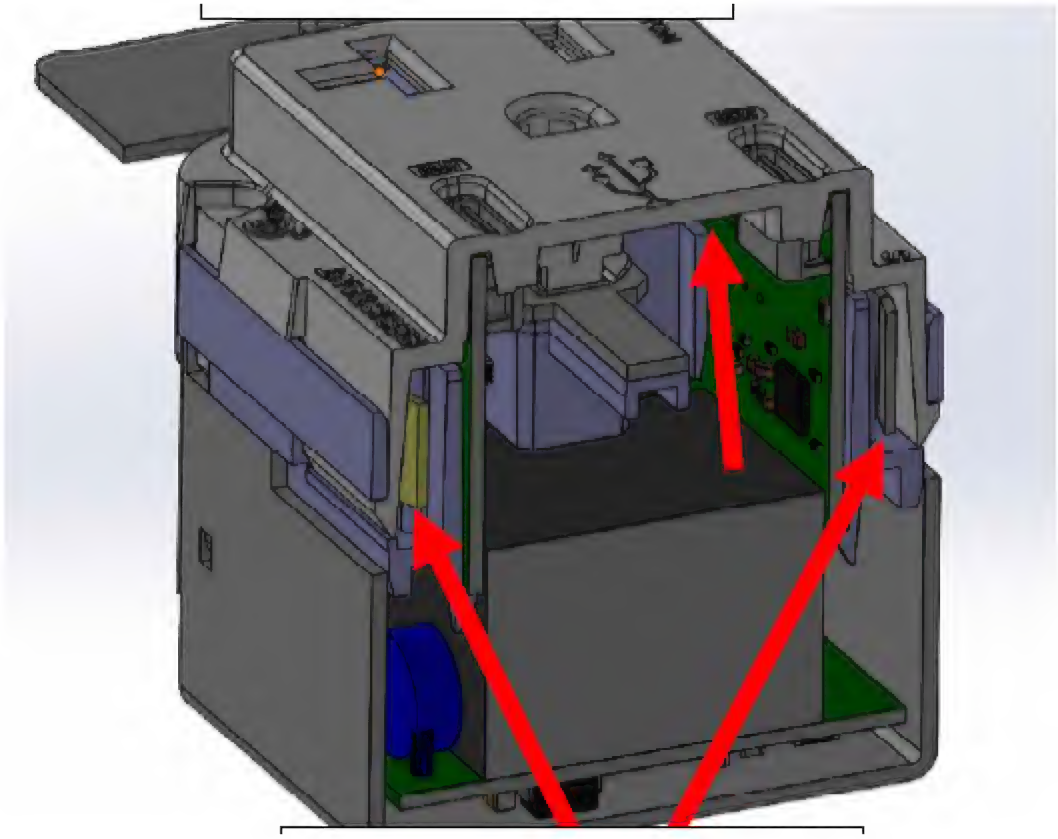

FIG. 5

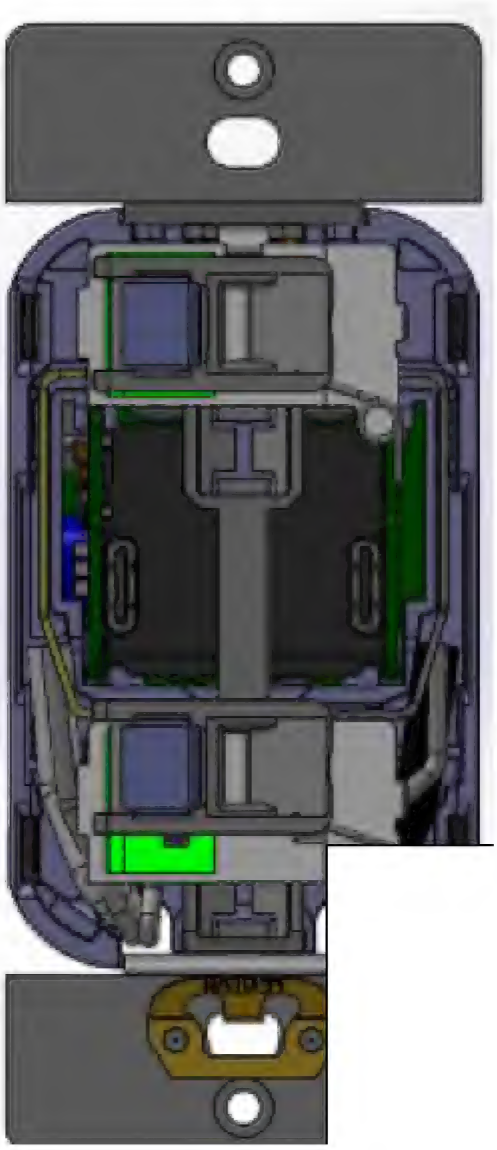

FIG. 6

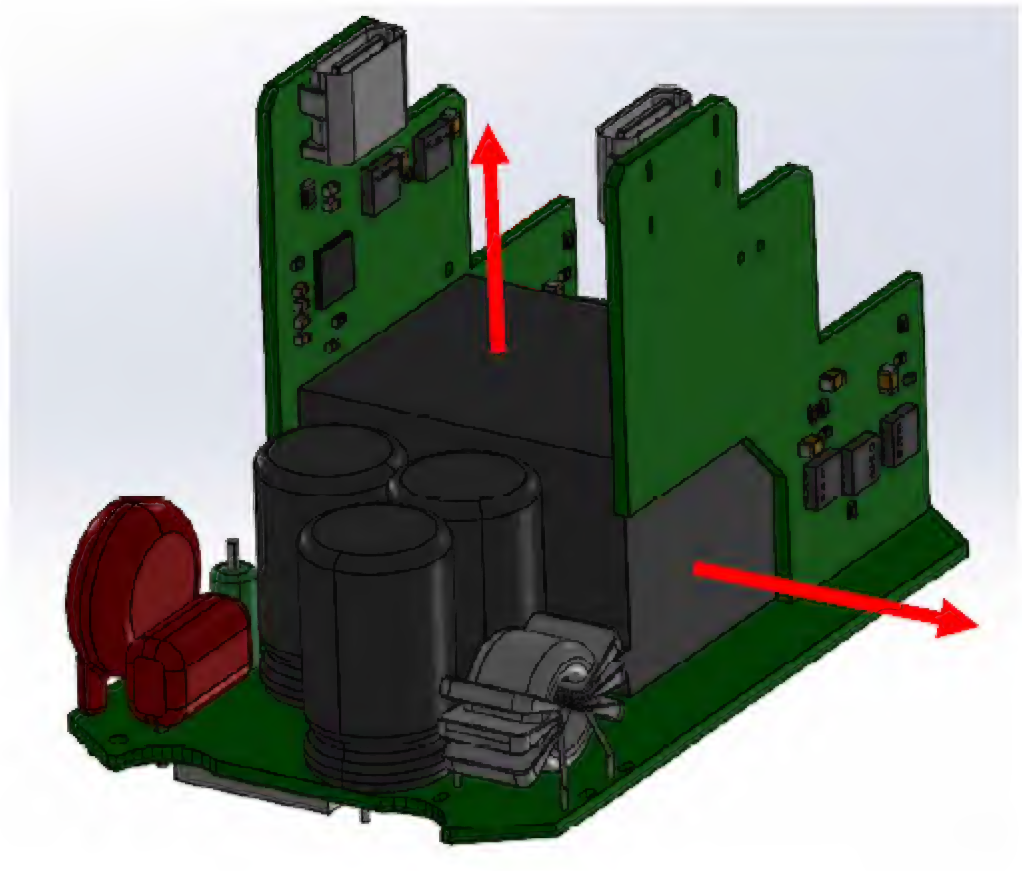

FIG. 7

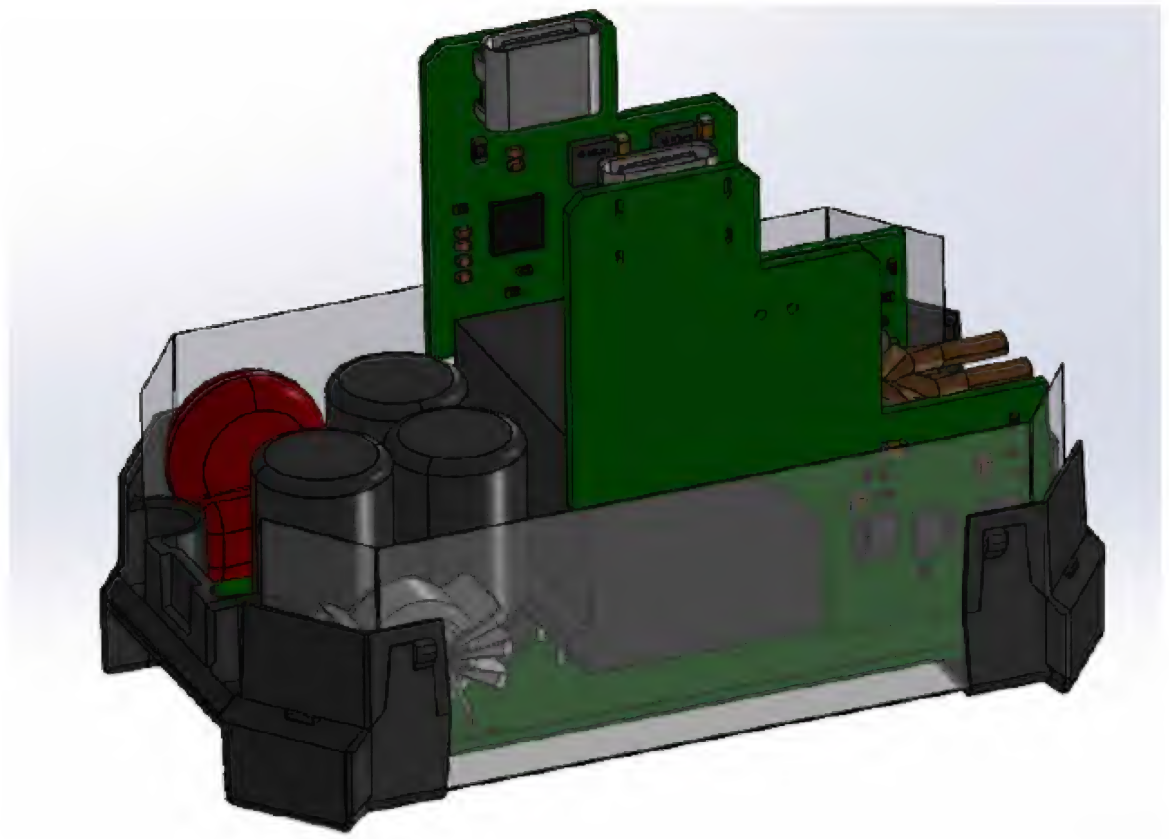

FIG. 8

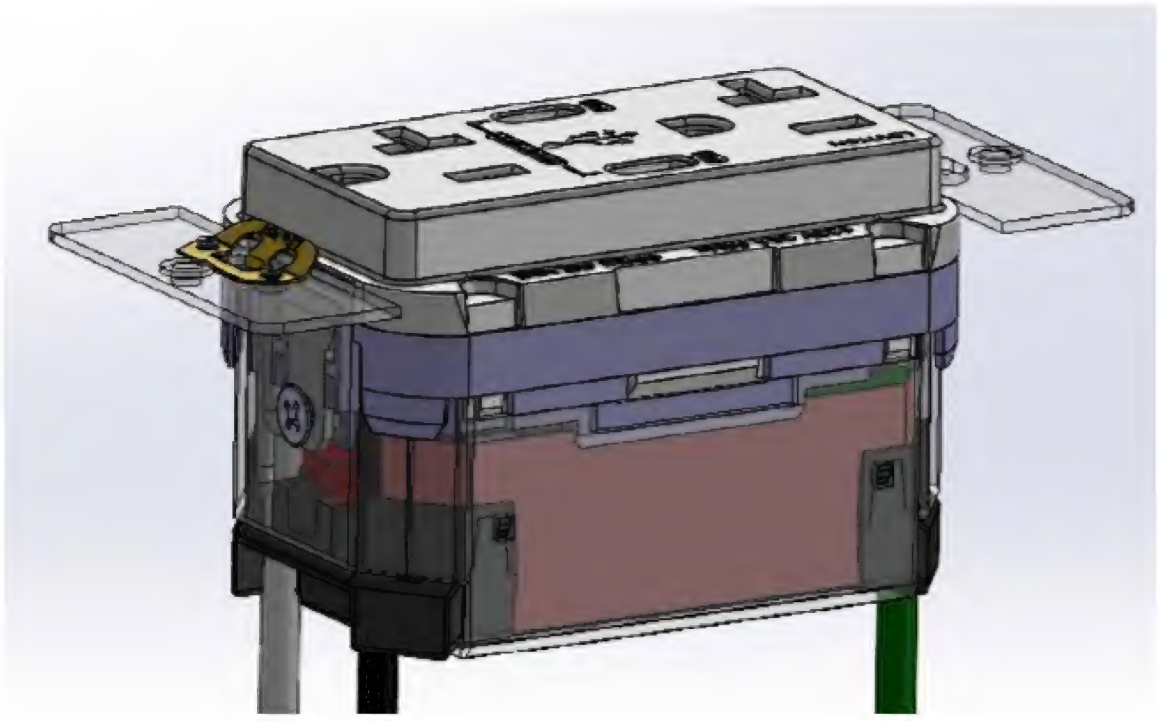

FIG. 9

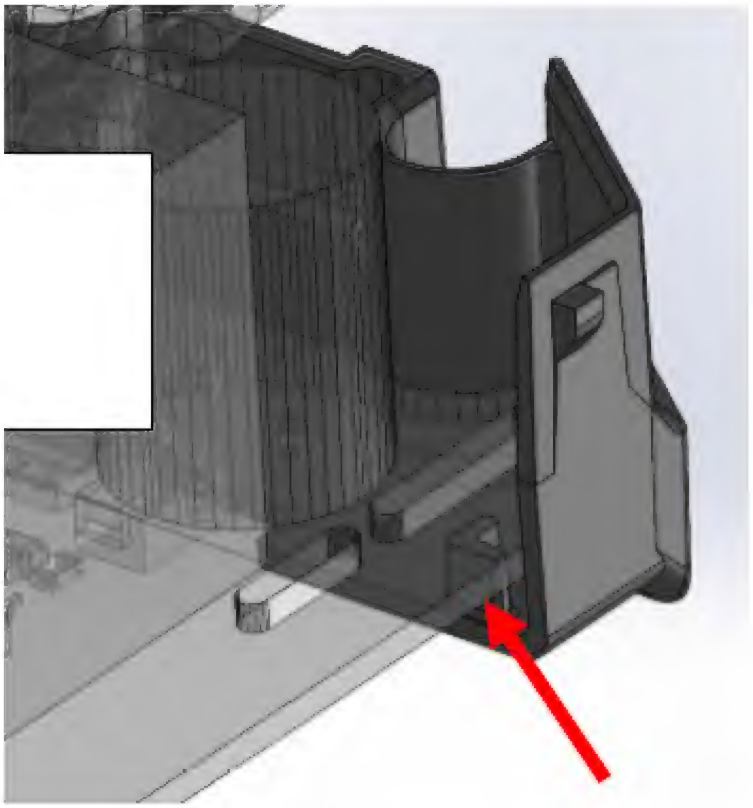

FIG. 10

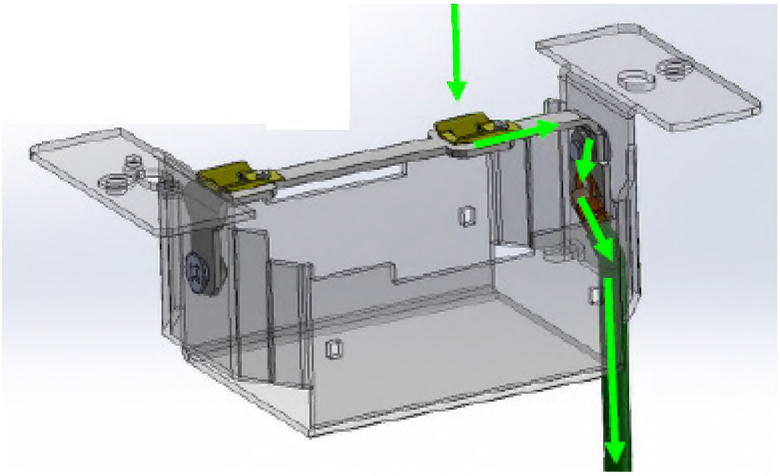

FIG. 11

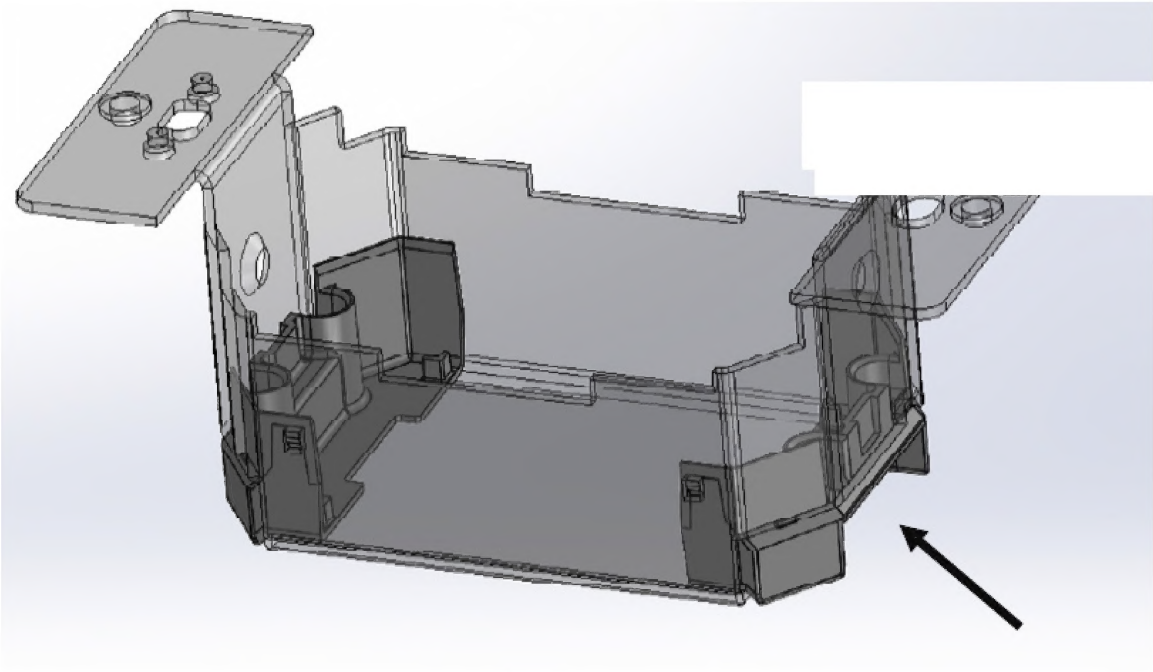

FIG. 12

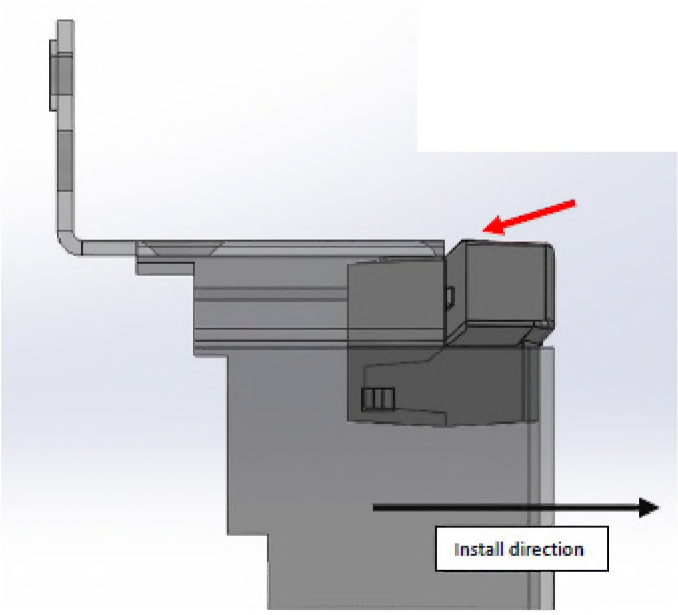

FIG. 13

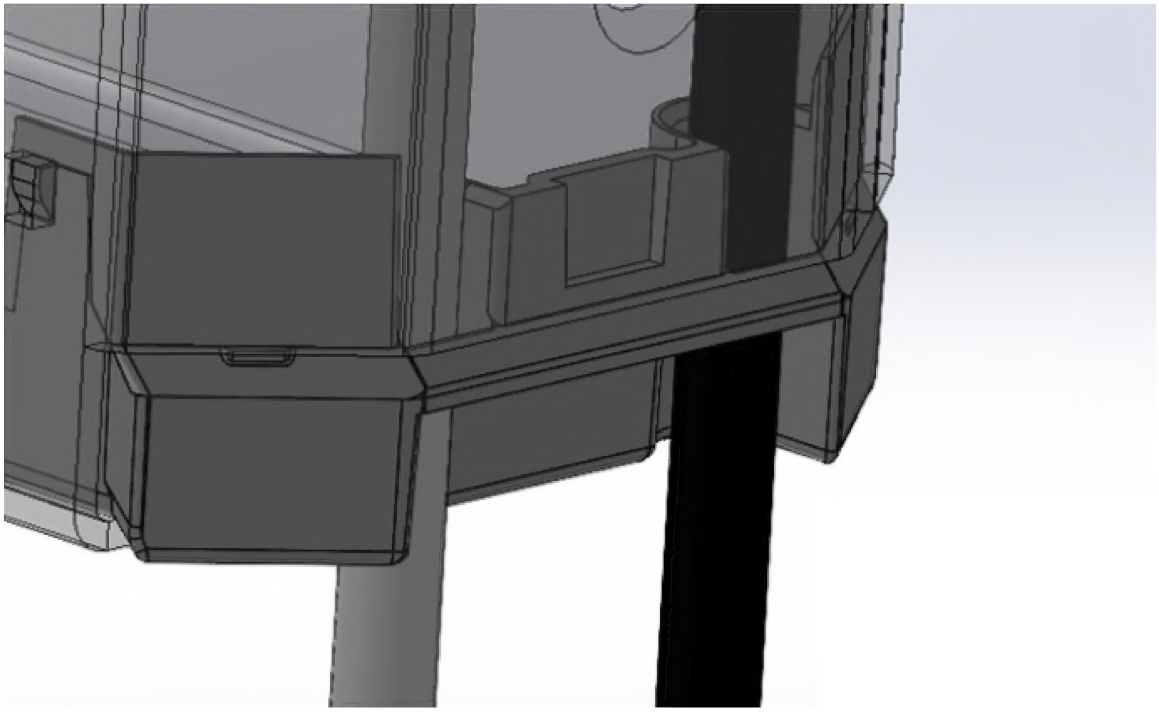

FIG. 14